CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-240
SUPPLEMENT #2

CUCAMONGA FAULT ZONE, EASTERN CUCAMONGA PEAK QUADRANGLE, San Bernardino County, California

by
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INTRODUCTION

This supplement to FER-240 (Burnett and Hart, 1994) has been prepared as a result of letters received from the City of Rancho Cucamonga (D. Coleman, Jan. 12 and Jan 31, 1995) regarding the use of two consulting reports located in the eastern part of the Cucamonga Peak Preliminary Earthquake Fault Zone (EFZ) Map issued December 1, 1994. Specifically, Coleman noted that traces mapped by Rasmussen and Associates (1989 - DMG file # AP-2431; 1990 - DMG file # AP-2750) had not been used in the compilation of the Preliminary EFZ Map of the Cucamonga Peak quadrangle and wanted to know if DMG was aware of these reports. The site reports are located in sections 16 and 17, T1N, R6W in the eastern part of the Cucamonga Peak 7.5-minute quadrangle (Figure 1). These reports were referenced in FER-240. However, a more detailed evaluation of the site investigations by Rasmussen and Assoc. (1989, 1990) was done by this writer as a result of the comments received from the City of Rancho Cucamonga. Three additional site investigations by Richard Mills Associates (1981), Soil and Testing Engineers, Inc. (1988), and ICG, Inc. (1989) were obtained for this supplement.

SUMMARY OF AVAILABLE DATA

MORTON AND MATTI (1987, 1991)

Traces of the Cucamonga fault zone shown on the Preliminary EFZ Map of the Cucamonga Peak quadrangle were based on mapping by Morton and Matti (1987, 1991). Two versions of mapping by Morton and Matti in the Cucamonga Peak quadrangle exist: a USGS Professional Paper published in 1987 at a scale of 1:24,000 (Morton and Matti, 1987, mapping was actually completed in the late 1970's and very early 1980's (J. Matti, p.c., February 1995)), and an Open-File Report published in 1991 at a scale of 1:24,000 (Morton and Matti, 1991). Traces of the Cucamonga fault zone in this study area (sections 16 and 17, T1N, R6W) were based on Morton and Matti's 1987 mapping (shown in purple on Figure 1).

Alluvial units mapped by Morton and Matti (1987) in the study area consist of alluvial fan and fluvial terrace deposits derived from crystalline basement rocks of the eastern San Gabriel Mountains (principally quartz diorite, diorite, and granulitic gneiss). The oldest alluvial unit in the study area (Qdf_2) is a mid-Pleistocene dissected alluvial fan deposit that underlies the site of the Day Canyon Station. Latest Pleistocene to Holocene alluvial fan unit Qyf_1, Holocene alluvial fan units Qyf_2 , Qyf_2 (oldest), Qyf_3 , and Qyf_3 Qyf_4 (youngest), and late Holocene alluvial fan (Qf) and active channel and wash deposits (Qw) underlie the study area. The most important units with respect to this FER supplement are Qyf_1 and Qyf_2. The relative age of these units is based on the degree of preservation of constructional geomorphic surfaces, degree of weathering of basement clasts, and degree of soil profile development.

Traces of the Cucamonga fault zone mapped by Morton and Matti (1987) consist of three principal branches or strands in the study area: Strand A is the northernmost branch, Strand B is the central branch, and Strand C is the southernmost branch (Figure 1). Strands A and B merge in the western and eastern ends of the study area. Traces of Strand B in the easternmost part of section 17 and western part of section 16 are complex and locally consist of three branches (Figure 1). Strand C is the principal active trace in the study area and offsets all but the youngest (late Holocene) alluvial deposits. Strand B offsets Qyf_1 and Qyf_2 alluvial deposits throughout most of the study area. Strand A offsets older, dissected alluvium (Qdf_2) and locally was mapped as offsetting latest Pleistocene to Holocene alluvium (Qyf_1) at localities 1 and 2 (Figure 1).

Later mapping by Morton and Matti (1991) generally is the same as their 1987 map with the exception of Strand A (1991 traces not shown on Figure 1). Specifically, traces of Strand A at localities 1 and 2 are mapped as concealed by Qyf_1 (Morton and Matti, 1991). Strand A 400 feet (122m) southeast of locality 2 is also depicted as offsetting modern alluvium (Qw) in the 1987 version (possible drafting error?). The fault trace here is mapped as concealed in the 1991 map. One additional change occurs 600 feet (183m) east of locality 1 where the concealed trace of Strand A (1987 version) is mapped as approximately located in <u>younger</u> Qyf_2 alluvium for about 500 feet (152m) in the 1991 version.

AERIAL PHOTOGRAPHIC INTERPRETATION

U.S. Department of Agriculture aerial photographs (AXL, 1953) were used to photo check traces of the Cucamonga fault zone mapped by Morton and Matti (1987, 1991) and Rasmussen and Associates (1989, 1990), as well as to compile a reconnaissance photo interpretation map by this writer (Figure 2). Approximately 1/2 day was spent field checking selected traces of the Cucamonga fault zone in late April 1995 by this writer and J. Treiman. In general, Strand A is moderately to poorly defined and lacks geomorphic features indicative of Holocene surface fault rupture. Strand B is moderately well to locally well defined by scarps and linear tonal contrasts in latest Pleistocene and Holocene alluvium (Figure 2). Strand C is delineated by a well-defined south-facing scarp in Holocene alluvium through all but the easternmost part of the study area (Figure 2). East of section 16, the south-facing scarp delineating Strand C is difficult to follow and may be manifested as a subtle break in slope (Figure 2). Specific details of the geomorphic expression of traces of the Cucamonga fault zone appear with the discussion of the trench investigations below.

CONSULTING REPORTS

Five site specific fault investigations have been completed in the study area, including Rasmussen and Associates (1989 - AP-2431; 1990 - AP-2750), Richard Mills Associates, Inc. (1981), Soil and Testing Engineers, Inc. (1988), and ICG, Inc. (1989). Fault traces mapped by Rasmussen (1989, 1990) are plotted in black on Figure 1. The location of trench excavations by Rasmussen (1989, 1990), Richard Mills (1981), and Soil and Testing Engineers (1988) are plotted on Figure 1. Trench 14 from ICG (1989) is also shown on Figure 1.

Rasmussen and Associates (1989) excavated 18 trenches totalling about 9,500 feet (2895m) and mapped traces of the Cucamonga fault zone at a scale of 1" = 200' for a site investigation for the Oak Summit development (Figure 1). The site investigation was designed using the mapping of Morton and Matti (1987). Soil and Testing Engineers (1988) investigated the Oak Summit area, excavating 20 trenches totalling about 6,000 linear feet (1829m) (Figure 1). Richard Mills (1981) excavated 13 trenches across traces of the Cucamonga fault zone in the Oak Summit area. The location of the Mills trenches are shown on Figure 1, but I was unable to obtain copies of trench logs for evaluation in this FER supplement. Rasmussen (1990) investigated the adjacent site to the east (Etiwanda Heights development) (Figure 1). This site investigation included the excavation of fourteen trenches totalling about 6,000 linear feet (1829m) and mapping at a scale of 1" = 200'. ICG, Inc. (1989) excavated 16 trenches across traces of the Cucamonga fault zone in the Etiwanda Heights development. Only trench ICG-14 is plotted on Figure 1.

Soil Profiles

L. McFadden of the University of New Mexico described soil profiles at selected sites exposed in Rasmussen's (1989) trenches T-1 and T-4 (Figure 1). Three soil profiles were described in T-1, a 1,731-foot (528m) long trench excavated to depths of about 12 feet (3.6m). Soil profile 1, at sta. 435 (sta. 0 at northern end of trench), is developed in unit 27, a sandy gravel alluvial deposit containing moderately weathered granitic and gneissic clasts and highly weathered diorite clasts (all unit numbers are from Rasmussen, 1989). The soil (unit 2) developed on unit 27 is characterized by a cambic B horizon and is estimated by McFadden to be between 8ka and 15ka. This unit probably correlates with Morton and Matti's Qyf_1 alluvial unit. Soil profile 2, at sta 1015, is developed on unit 16 (and 17), a silty sand with gravel and boulder deposit. This alluvial unit lacks the degree of weathering of crystalline basement rock clasts seen in unit 27 alluvium. The soil profile contains an incipient B_w horizon and is estimated by McFadden to be between 6ka and 8ka (unit 2). Alluvial unit 16 (and 17) probably correlate with Morton and Matti's Qyf_2 alluvial unit. Soil profile 3, at sta. 1409, is developed in alluvial units 16 and 17. The soil profile lacks the B_w horizon in soil profile 2. McFadden estimated an age of 2ka to 4ka. This alluvial unit may correlate with Morton and Matti's Qyf_2 or Qyf_3 alluvial units.

Two soil profiles were described in T-4, a 3,006-foot (916m) long excavated to depths of 14 feet (4.3m). Soil profile 4, at sta. 637 (sta. 0 at northern end of trench), is developed on unit 29 alluvium, a silty sand with gravel and boulders that overlies unit 17. The soil profile is an AC horizon extending to a depth of 4 feet (1.2m). McFadden estimated the age of the soil (units 1 and 2) to be between 4ka and 6ka. Alluvial unit 29 probably correlates with Morton and Matti's Qyf_2 alluvial unit. Soil profile 5, at sta. 330, is developed in alluvial unit 26, a gravelly sand with diorite, granitic, and gneissic clasts altered to grus. The soil profile is delineated by multiple B_t horizons to a depth of about 5 1/4 feet. Unit 4 is described as an argillic soil horizon with 7.5 YR colors. The age of the soil profile is estimated by McFadden to be between 12ka and 60ka. Unit 26 alluvium at this trench station is located in Morton and Matti's unit Qyf_2 alluvial unit, but probably correlates with Qyf_1 alluvium, or possibly an older unit.

Strand A

Five trenches were excavated across Strand A in section 17, including T-4 and T-17 of Rasmussen and Assoc. (1989), ST T-T, ST T-I, and ST T-G of Soil and Testing Engineers, Inc. (1988) (Figure 1). No evidence of faulting was reported in any of these trenches. Rasmussen's trench T-17 was located to cross Strand A where it offsets Qyf_1 alluvium as mapped by Morton and Matti (1987) (locality 1, Figure 1). This 451-foot (137m) long trench excavated to depths up to 15 feet (4.6m) exposed unfaulted unit 28 alluvium that is probably correlative with Morton and Matti's Qyf_1 alluvium, based on the degree of weathering of granitic, diorite and gneissic clasts. Trench T-4 (Rasmussen and Associates, 1989) is a 3,006-foot (916m) long excavation that crosses Strands A, B, and C mapped by Morton and Matti (Figure 1). T-4 crosses Strand A where Morton and Matti (1991) show an approximately located trace offsetting Qyf_2 alluvium (locality 3, Figure 1). Strand A should have been exposed at about station 160 in T-4. No evidence of faulting was reported in coarse alluvial deposits (unit 26) characterized by crystalline basement clasts weathered to grus (granitic, diorite, and gneissic) and a well-developed argillic soil horizon with 3 B_t horizons (McFadden's soil profile 5). I did not observe geomorphic evidence of Strand A between localities 1 and 3, based on air photo interpretation and limited field checking (Figures 1 and 2). Trenches by Soil and Testing Engineers (ST T-T, ST T-I, ST T-G) did not expose evidence of Strand A along the linear south-facing escarpment east of locality 3 (Figure 1).

Strand A in section 16 was crossed by nine trenches, including Rasmussen (1989 - T-1, T-2; 1990 - T-1, T-2, T-4A, T-5, T-6 , T-9), and ICG, Inc. (1989) (ICG-14) (Figure 1). The most significant trench is ICG-14, which crossed the trace of Strand A where it was shown by Morton and Matti (1987) as offsetting Qyf_1 (locality 2, Figure 1). The trench exposed latest Pleistocene to Holocene terrace deposits overlying weathered granitic bedrock. No evidence of faulting was observed in this 200-foot (61m) long trench excavated to a depth of 16 feet (4.9m). Strand A at the location of this trench is delineated by a vegetation contrast in the Qyf_1 surface (locality 2, Figure 2). A break in slope (or scarp?) at this location may also exist, but the scale of the 1953 USDA air photos is not sufficient to resolve this feature. Morton and Matti's 1991 map shows Strand A as concealed by Qyf_1 deposits at locality 2.

Strand B

The location and Holocene activity of Strand B as mapped by Morton and Matti (1991) is essentially the same as their 1987 version, the most significant difference occurring along a branch of Strand B at locality 4 (Figure 1). Their 1987 version of this branch of Strand B was shown as offsetting modern Qw alluvium; the 1991 map correctly shows the fault to be concealed by Qw alluvium. Traces of Strand B were trenched in several locations by Rasmussen (1989; 1990), Soil and Testing Engineers (1988), Richard Mills (1981), and ICG, Inc. (1989) (Figure 1).

The most significant trenching data for Strand B was developed by Rasmussen (1989; T-4, 5, and 6), Richard Mills (1981; M T-1, 2, and 6), and Soil and Testing Engineers (1988; ST T-R, T-Q, T-Q, T-K) near the site of the former Day Canyon Ranger Station in the western half of section 17 (Figure 1). Instead of a single trace mapped by Morton and Matti, a fault zone up to 225 feet (68.6m) wide consisting of two to three traces was mapped by Rasmussen (1989). An 84-foot (25.6m) wide fault zone was exposed from sta. 436 to 520 in Rasmussen's trench T-4. The northernmost fault offsets unit 16 alluvium and displaces unit 2 soil about 1.8 feet (0.55m) (dip slip offset), demonstrating Holocene displacement. This fault has an unusual attitude (N63°E 49°NW). It is possible that the strike should be NW because the fault trace mapped by Rasmussen here strikes NW. The principal fault at station 453 (N80°E 47°W) offsets unit 16 alluvium, but does not offset unit 2 soil. Two traces of Strand B were exposed in Rasmussen's trench T-5. The northern trace (N85°W 21°NE) at station 22 offsets fractured bedrock on the north over thick colluvial deposits. The southern trace (N80°E 37°NW) at station 168 offsets a channel fill incised into mid Holocene (?) unit 17 alluvium and may extend into overlying colluvium, although the base of the colluvium is not offset. This southern branch of Strand B is delineated by a well-defined linear vegetation contrast near the base of the south-facing escarpment and a moderately well-defined scarp in Holocene alluvium to the east (Figures 1 and 2). The northern trace mapped by Rasmussen (1989) is delineated by a well-defined linear tonal contrast near the top of the large south-facing scarp and is delineated by a break in slope at the unpaved road at locality 5 (Figures 1 and 2). East of locality 5 this northern trace generally lacks geomorphic expression, but is well-defined in trench exposures (T-4, ST T-K) (Figure 1).

East of T-4 Strand B mapped by Rasmussen (1989; 1990) is mostly coincident with traces mapped by Morton and Matti (1987, 1991). Two exceptions are at localities 6 and 7 (Figure 1). At locality 6 trench excavations by Rasmussen (1990) (T-2, 4, 4A, 10 and 14) exposed traces located just north and south of the trace mapped by Morton and Matti, but did not verify the location of Morton and Matti's south-facing scarp (Figure 1). Geomorphic expression of Strand B at this location is not well-defined, being delineated by a general break in slope (Figure 2). However, this area has been somewhat modified by grading and farming. Morton and Matti mapped a concealed southern trace of Strand B in the south central part of section 16 (locality 7, Figure 1). Trenching by Rasmussen (1989; T-1) verified the location of a fault at locality 7. The fault (N78°E 30°NW) exposed at station 1286 offsets alluvial unit 29 on the north against unit 22 on the south. Unit 29 alluvium at this location has incised into the mid-Holocene (?) alluvial unit 16; the overlying unit 2 soil is not offset. The fault at locality 7 is delineated by a modified south-facing scarp and tonal lineament (Figure 2).

Strand C

Trenching by Rasmussen (1989, 1990), Soil and Testing Engineers, Inc. (1988), and Richard Mills (1981) mostly verified the location and activity of Morton and Matti's Strand C. This fault, unchanged in Morton and Matti's 1987 and 1991 mapping, is delineated by a generally well-defined south-facing scarp in latest Pleistocene and Holocene alluvium (Figures 1 and 2). Trench exposures of Strand C show that the fault offsets all Holocene units and deforms the overlying A soil horizon, demonstrating late Holocene displacement. The SE 1/4 of section 16 (locality 8, Figure 1) is the only location where trenching did not verify the exact location of Strand C as mapped by Morton and Matti. Here trenching by Rasmussen (1990) indicates that the fault is located about 100 feet (30.5m) north of Morton and Matti's Strand C.

CONCLUSIONS

Traces of the Cucamonga fault zone that were established for Earthquake Fault Zones (Preliminary) in the eastern Cucamonga Peak quadrangle (sections 16 and 17, T1N, R6W) based on mapping by Morton and Matti (1987) generally are sufficiently active and well-defined. Morton and Matti recognized three general branches, or strands, that comprise the Cucamonga fault zone. These branches are, from north to south: Strand A, Strand B, and Strand C (Figure 1).

Strand A in sections 16 and 17 is moderately to poorly defined by south-facing scarps and faceted spurs in bedrock, based on air photo interpretation by this writer (Figure 2). Morton and Matti (1987) mapped latest Pleistocene to early Holocene alluvium (Qyf_1) offset at localities 1 and 2 (Figure 1). The 1991 version of their map, however, shows this alluvium as concealing Strand A at these localities. A total of 14 trenches excavated across traces of Strand A by Rasmussen and Associates (1989) (T-1, T-2, T-4, T-17), Rasmussen and Associates (1990) (T-1, T-2, T-4A, T-5, T-6, T-9), Soils and Testing Engineers (1988) (ST T-G, ST T-I, ST T-T), and ICG (1989) (ICG-14) did not verify the location or activity of Strand A (Figure 1). Rasmussen (1990) concluded that Strand A is buried beneath alluvium of Holocene and Pleistocene age and considers this strand to be neither active nor potentially active.

Strand B is moderately to locally well-defined, based on air photo interpretation by this writer (Figure 2). Traces mapped by Morton and Matti (1987) recommended for zoning are essentially unchanged from their later 1991 map. Traces of Strand B offset latest Pleistocene and Holocene alluvium. Site investigations by Rasmussen (1989), Richard Mills (1981), and Soil Testing Engineers (1988) generally verified Holocene active traces mapped by Morton and Matti except in the western part of section 17. Here they found that, instead of a single trace, Strand B is characterized by two to three traces in a zone up to 225 feet (68.6m) wide (Figure 1). Strand B becomes more complex in the eastern part of section 17 and section 16 (Figure 1).

Trenching by Rasmussen (1989; 1990) and Soil and Testing Engineers (1988) mostly verified the location of Strand B traces mapped by Morton and Matti (1987). Exceptions are at locality 6, where trenching by Rasmussen (1990) verified faults just north and south of Morton and Matti's trace and at locality 7 were trenching by Rasmussen (1989) showed that this trace extended farther east and offset Holocene alluvium (Figure 1).

Strand C, considered to be the most active branch of the Cucamonga fault zone in the study area, is delineated by a well-defined scarp in Holocene alluvium (Morton and Matti, 1987, 1990) (Figures 1 and 2). Site investigations by Rasmussen (1989; 1990), Richard Mills (1981), Soil and Testing Engineers (1988), and ICG (1989) have demonstrated that Strand C is Holocene active (offsets late Holocene soil) and have verified the location of the trace as mapped by Morton and Matti (Figure 1).

RECOMMENDATIONS

Recommendations for establishing Earthquake Fault Zones are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1994).

Strand A

Delete traces of Strand A in sections 16 and 17 on the Preliminary EFZ Map of the Cucamonga Peak quadrangle as shown on Figure 3. Traces mapped by Morton and Matti (1987, 1991) are not sufficiently active.

Strand B

Modify traces of Strand B shown on the Preliminary EFZ Map of the Cucamonga Peak quadrangle, based on mapping by Rasmussen and Associates (1989 and 1990) as depicted on Figure 3.

Strand C

Modify the easternmost part of Strand C shown on the Preliminary EFZ Map of the Cucamonga Peak quadrangle, based on mapping by Rasmussen and Associates (1990) as depicted on Figure 3.

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REFERENCES

Burnett, J.L and Hart, E.W., 1994, Holocene faulting on the Cucamonga, San Jacinto, and related faults, San Bernardino County, California: California Division of Mines and Geology Fault Evaluation Report FER-240, 30 p. (unpublished).

Hart, E.W., 1994, Fault-rupture hazard zones in California: California Department of Conservation, Division of Mines and Geology Special Publication 42, 34p.

ICG, Incorporated, 1989, Feasibility geotechnical investigation, fault hazards evaluation, 160± acre residential development, 1.1±mi north of 24^t Street, west of Wardman Bullock Road, Etiwanda Area, San Bernardino County, California: Redlands, California, unpublished consulting report for Etiwanda Heights Development Corp., ICG, Incorporated Project no. 07-7989-001-00-00, October 20, 1989. 25 p., 16 plates.

Richard Mills Associates, Inc. 1981, Seismicity investigation, Lewis Homes Etiwanda Property in the City of Etiwanda, California: Rancho Cucamonga, California, unpublished consulting report for Lewis Homes, Richard Mills Associates, Inc. Project no. S-306, March 24, 1981, 10 p.

Morton, D. M. and Matti, J. C., 1991, Geologic map of the Cucamonga Peak 7.5-minute quadrangle, San Bernardino County, California: U.S. Geological Survey Open-Fila Report OFR 90-694, scale 1:24,000.

Morton, D. M. and Matti, J. C., 1987, The Cucamonga fault zone: Geological setting and Quaternary history, in Recent reversed faulting in the Transverse Ranges, California: U.S. Geological Survey Professional Paper 1339, p. 179-203.

Gary S. Rasmussen and Associates, 1990, Subsurface engineering geology and geotechnical feasibility investigation, 160-acre residential development, portion of section 16, T1N, R6W, SBB&M, Rancho Cucamonga area, San Bernardino County, California: San Bernardino, California, unpublished consulting report for Etiwanda Heights Development Corporation, Rasmussen and Associates Project no. 2837, April 18, 1990, 20 p., 6 enclosures, 1 appendix, 1 plate. (DMG file # AP-2750)

Gary S. Rasmussen and Associates, 1989, Subsurface engineering geology and geotechnical feasibility investigation, proposed Oak Summit development, Rancho Cucamonga area, California: San Bernardino, California, unpublished consulting report for Landmark Land Company, Rasmussen and Associates Project no. 2739, December 29, 1989, 23 p., 7 enclosures, 2 appendices, 1 plate. (DMG file # AP-2431)

Soil and Testing Engineers, Inc. 1988, Alquist-Priolo geologic investigation, Rancho Etiwanda development, portions of sections 16, 17, and 18, T1N, R6W, SBB&M, Rancho Cucamonga, California: San Bernardino, California, unpublished consulting report for Coussoulis Development Company, Soil and Testing Engineers, Inc. Project no. STE 8851038, December 15, 1988, 28 p., 23 plates.

U.S. Department of Agriculture, 1953, Aerial photographs AXL 35K- 87 to 89, 114 to 116; 36K- 136 to 138, black and white, vertical , scale approximately 1:20,000.